Impact Assessment of Revised Retroreflectivity Requirements for the State of Montana Phase II - Final Report

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16. Abstract

Traffic signing is a critical component of the roadway, as it is the communication medium by which motorists receive information relative to warnings, regulations, and guidance. Night-time legibility is very important to the effectiveness of roadway signs. Although external sign illumination is effective, the use of retroreflective sheeting is the most common and cost effective means of making signs visible to the driver at night.

This report focuses on the collection and analysis of a sample of traffic signs, delineated according to Montana Department of Transportation (MDT) District and sign type, on the State highway system. These samples were collected on the Montana highway system, focusing on non-Interstate, non-urban areas. This data allows cost estimates to be made for suggested sign replacements by sign category, as well as indicate appropriate and feasible replacement strategies and priorities within each MDT District and the State as a whole. Recommendations are made relative to sign management systems to easily and effectively target and document signs for future maintenance. This report details work activities associated with each of the study tasks, and concludes with findings and recommendations for Montana's course of action regarding the inventory of highway signs.

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Statement of Problem

An examination of accident statistics confirms that driving at night is more dangerous than driving during the day. Nationally, approximately 50 percent of all fatalities occur at night while only 25 percent of travel occurs at night. This translates to a fatality rate (fatalities/vehicle miles traveled) that is more than three times higher at night than during the day. (1)

A variety of factors contribute to this day/night disparity, including fatigue, intoxication and weather. However, drivers depend to a large extent on traffic control devices for warning, regulation, and guidance. As visibility conditions become poorer at night, this dependence increases. Many of the clues used by the driver for visual guidance during the day, disappear at night. The addition of possible inclement weather and glare from opposing vehicle headlights serve to compound the problem. The basic requirement for any traffic control device is that it must be visible and easily understood in time to permit the proper response by the driver. Because of gradual deterioration in visual acuity with age of driver, or due to the effects of weather or vandalism, many traffic control devices fail to meet this basic requirement at night. (2)

Traffic signing is a critical component of the road because it is the medium by which the highway agency communicates with the motorist, providing information relative to regulations, warnings and directional guidance. Roadway signs must be legible and their color distinguishable at night as well as during the day. Although this can be accomplished through external illumination of the signs, retroreflection is the most commonly used means of making signs visible to the driver at night. Retroreflection is reflection in which light is redirected back to its source. (3)

The Manual on Uniform Traffic Control Devices (MUTCD) requires that signs "….shall be reflectorized or illuminated to show the same shape and color both day and night." For the vast majority of traffic signs on our nation's roadways, nighttime visibility is achieved through the use of retroreflective sheeting of various types. (4) There are four sign-related factors that affect a sign's nighttime visibility:

1. Brightness, or the amount of light reflected from the sign that reaches the driver's eye;
2. Contrast, both internal (background-copy) and external (sign-environment);
3. Conspicuity, or the probability that a sign located in the visual periphery will be seen at a given distance; and
4. Legibility.

All these factors are influenced by the retroreflective characteristics of the sign sheeting material used. Over time, the retroreflective sheeting deteriorates with a subsequent loss in brightness, color, and contrast; the net effect is a reduction in its detection and legibility distance. (5)

Until recently, no objective measures existed to determine when a traffic sign had reached the end of its service life and required replacement. This need was addressed by the Federal Highway Administration (FHWA) Office of Safety and Traffic Operations Research and Development with a research program initiated to establish minimum retroreflectivity requirements for traffic signs. (6) The results of this effort are given in Tables 1-4. Tables 1-4 are left in English units, as called out by the FHWA in the proposed revised retroreflectivity standards.

The sign material sheeting classifications (I-IV) referred to in the minimum retroreflectivity guidelines correspond to the following American Standards for Testing and Materials (ASTM) types: (3)

Type I - (Engineering Grade) A medium intensity sheeting; enclosed lens glass-bead material.

Type II - (Super Engineering Grade) A medium-high intensity sheeting; enclosed glass-bead material.

Type III - (High Intensity) A high intensity sheeting; encapsulated glass bead or prismatic material.

Type IV - (High Performance) A high intensity sheeting; non-metallized micro-prismatic element material.

Table 1: Minimum Retroreflectivity (cd/lx/m^2) Guidelines for Black/White Regulatory and Guide Signs. (6)

Legend Color: Black and/or Black and Red **Background Color:** White

	Traffic Speed:	45 mi/hr or greater			40 mi/hr or less		
	Sign Size:	>=48 in	30-36 in	<=24 in	>=48 in	30-36 in	<=24 in
	Material						
Ground Mounted	I	20	35	50	15	20	35
	II	25	45	70	20	30	55
	III	30	60	90	25	45	75
	IV & VII	40	80	120	35	60	100
Overhead Mounted	I				40	50	100
	II				50	75	135
	III				65	115	185
	IV &VII				90	150	250

1 mi/h = 1.6 km/h 1 in = 25.4 mm

Table 2: Minimum Retroreflectivity (cd/lx/m^2) Guidelines for Black/Yellow and Black/Orange Warning Signs. (6)

Legend Color: Black **Background Color:** Yellow or Orange

	Sign Size:	>=48 in	36 in	<=30 in
Legend	Material Type			
Bold Symbol	ALL	15	20	25
Fine Symbol & Word	I	20	30	45
	II	25	40	60
	III	30	50	80
	IV	40	70	120

1 mi/h = 1.6 km/h 1 in = 25.4 mm

Table 3: Minimum Retroreflectivity (cd/lx/m^2) Guidelines for White/Red Regulatory Signs. (6)

Legend Color: White **Background Color:** Red

Traffic Speed:	45 mi/hr or greater						40 mi/hr or less					
Sign Size:	>=48 in		36 in		<=30 in		>=48 in		36 in		<=30 in	
	W	R	W	R	W	R	W	R	W	R	W	R
All Signs	50	10	60	12	70	14	30	6	35	7	40	8

1 mi/h = 1.6 km/h 1 in = 25.4 mm

Table 4: Minimum Retroreflectivity (cd/lx/m^2) Guidelines for White/Green Guide Signs. (6)

Legend Color: White **Background Color:** Green

Traffic Speed:	45 mi/hr or greater		40 mi/hr or less	
	White	Green	White	Green
Ground Mounted	35	7	25	5
Overhead Mounted	110	22	80	16

1 mi/h = 1.6 km/h 1 in = 25.4 mm

The need for the developed minimum retroreflectivity guidelines was further reinforced by federal legislation in 1993. Section 406 (a) of the 1993 DOT Appropriations Act requires the Secretary of Transportation to revise the Manual on Uniform Traffic Control Devices to include a standard for minimum levels of retroreflectivity that must be maintained for traffic signs and pavement markings. (7)

The need to replace numerous signs in order to comply with the proposed minimum retroreflective values was not discounted by FHWA. Table 5 estimates the percentage of sign replacement by jurisdiction type that would likely result if their guidelines were ultimately adopted. (8) Several states have already conducted studies to determine the replacement impact of implementing the proposed FHWA retroreflectivity requirements. (9,10,11,12)

Table 5: Estimated Sign Replacement by Jurisdiction Type.

Type of sign (Color)	Aggregate Replacement Value[1]	State	County	City	Town	Combined
Warning (Yellow)	42	7%	4%	10%	1%	8%
Regulatory (Red)	11	10%	6%	23%	16%	16%
Regulatory (White)	58	7%	8%	17%	4%	10%
Guide (Green)	6	12%	7%	11%	0%	11%

[1] $cd/lx/m^2$

It is equally important for the Montana Department of Transportation (MDT) to reasonably assess the level of compliance by existing State roadway signs with the proposed FHWA minimum retroreflectivity requirements and establish a feasible strategy for replacement and future sign management.

Background - Phase I

Based upon the recognized need by the Montana Department of Transportation (MDT) for an impact assessment and replacement strategy in response to the proposed FHWA revised minimum retroreflectivity guidelines for roadway signs, a two-phase study was initiated in March of 1995 to be conducted by Montana State University (MSU). Phase I of the project effort was completed in September of 1995 and included the following task activities:

Task A - Literature Assimilation, Review and Analysis

Task B - Multi-State Phone Solicitation of Policy/Strategies

Task C - Assessment of Equipment and Methodology for Sign Reflectivity Inspection

Task D - Evaluation/Modification of Current Sign Inventory

Task E - Recommendations for Impact Assessment and Implementation

Details of work progress in Phase I were described in a final report published in September of 1995. (13) Preliminary findings and recommendations are summarized from that report as follows:

- Many other states, in response to the proposed FHWA minimum sign retroreflectivity requirements, have developed a multi-year plan for complete highway sign replacement with up graded sheeting. Although this might be an appropriate long-term goal of the Montana Department of Transportation, it may be prudent to delay any similar decision until the proposed retroreflectivity requirements are formally adopted in the MUTCD.

- Use of the portable reflectometer equipment (Advanced Retro Technologies, Inc. model 920) in the field for numerical measurements of sign reflectivity is cumbersome, time consuming, labor intensive and costly unless incorporated with other sign inventory data collection activities. Utilization of the FHWA Mobile Sign Reflectometer Van as an expedient measurement tool should still be investigated, possibly in Phase II of this study. Controlled spotlight assessment for sign replacement due to diminished reflectivity seems to be a

workable alternative, although definite and viable procedures for this technique need to be established.

- Preliminary sign retroreflectivity measurements taken in the Montana Department of Transportation's Butte District will allow the determination of a statewide sampling plan to be conducted in Phase II of this study. This sampling plan and methodology will be based on minimum cell sampling techniques, which can be accomplished within the time and budget constrains of the research contract.

- Currently, there is no significant or consistent collection or maintenance of sign inventory data for effective replacement management in Montana. Studies by other states have emphasized that, while necessary, the institution of an effective sign management system with the associated data collection is a costly endeavor. Recognition of this has led FHWA to develop and offer a micro-computer based Sign Management System (SMS), with support and training, to state DOT's. It is recommended that MDT adopt this system for the stated purpose. It is further proposed that to assist MDT in implementation of the SMS, the research study conduct a pilot demonstration of this system utilizing sign inventory data collected in the Butte District.

The acceptance of these stated preliminary results by the Montana Department of Transportation was the basis for progressing into Phase II of the research project.

Scope of Work - Phase II

Phase II of the study, which began in September of 1995, extended the previous work activities to include the following tasks:

Task F - Procure and Test Reflectometer Equipment

Task G - Establish Sampling Procedures and Methodology

Task H - Conduct Statewide, District Sampling of Sign Retroreflectivity

Task I - Analyze and Summarize Field Sampling Data

Task J - Prepare a Final Report of the Study Findings

Task K - Training and Implementation of the Sign Management System Inventory

The overall objective for Phase II was to conduct a state-wide sampling, by District, of all current traffic signs on the State highway system. This has allowed cost estimates to be made of required sign replacements by sign category, as well as indicate appropriate and feasible replacement strategies and priorities. Recommendations are also made relative to sign management systems to easily and effectively target and document signs for future maintenance. The remainder of this report details work activities associated with each of the Phase II tasks.

Task F - Procure/Test Retroreflectometer Equipment

Portable Retroreflectometer

Advanced Retro Technologies Inc.(ART) produces a line of commercially available portable retroreflectometers for daytime measurement of sign retroreflectivity. This study used data collected with the ART 920, made available through the Montana Department of Transportation. The ART 920 is supplied with instructions for use, calibration disks consisting of different sign material types and colors for calibration to the corresponding sign legend and background materials. The measurements recorded are coefficients of retroreflection (R_A), the ratio of luminous intensity of the reflecting surface to its area, expressed in candelas per lux per square meter (cd/lx/m^2).

The ART 920 emits a strong beam of light that illuminates an approximate area of 1.0 square inch of the sign face. The intensity of the returned light, or retroreflected light, is measured and used to determine the coefficient of retroreflection, or R_A. To maintain precision and consistency, each measurement involves calibration of the device to the proper color and material type, and the use of a large circular disk attachment on the front of the unit to ensure that the reflectometer maintains its orthogonal position relative to the sign face. In addition, the area to be measured must be free of damage, dirt or debris to ensure accurate results for each sign reflective reading.

The ART 920 Retroreflectometer has its disadvantages. Measurement of each sign involves considerable time, as it requires the inspector to be at the sign location to make multiple measurements of the sign face. Measurement of tall or overhead signs requires the use of either ladders, a basket truck, or and attachment that is available from Advanced Retro Technologies, Incorporated. This attachment allows for operation of the trigger mechanism through a switch mounted at the bottom of the extension. Use of this attachment is a very difficult operation due to wind, sway of the sign, and operator instability. These factors result in difficulty obtaining a truly orthogonal orientation of the instrument to the sign face. Periodic maintenance consisting of mirror calibration and quality assurance of the light-sensitive measurement devices is necessary. Finally the sensitive nature of these components cause the unit to be fragile.

Mobile Sign Retroreflectivity Van

The ability to perform sign reflectivity measurements in a more time-efficient manner would be extremely valuable, especially to agencies with large jurisdictions, such as Montana. The Federal Highway Administration (FHWA) has developed both a first and second generation Traffic Sign Evaluator (TSE). The TSE is a mobile sign retroreflectivity measuring device that is housed in a conventional van and is capable of measuring the retroreflectivity level of a sign during the day at speeds up to 88 km/hr (55 miles per hour). This system will allow periodic inspection of the retroreflectivity levels of all traffic signs to be performed more efficiently in comparison to traditional methods. The Traffic Sign Evaluator will be an effective tool for sign measurement, but is likely to be an expensive alternative. The projected cost is approximately $100,000.

The TSE was to be developed and available for operational tests by the summer of 1996. Initially, plans for acquisition, testing, and analysis of results obtained through use of this device were to be included in this research. Problems with quality assurance delayed the projected date of availability, and current estimates indicate the sign inventory van will not be available until the Spring of 1997, with operational testing to be made available to State Departments of Transportation at that time. It has been discussed and requested for the Montana Department of Transportation to be given a demonstration and evaluation of the TSE by FHWA as soon as possible.

Retroreflectivity Assessment Technique

The Mississippi Department of Transportation has used a high-intensity spotlight, called the Q-beam, for daytime evaluation of sign retroreflectivity performance for several years. This technique involves the use of a 200,000 candlepower spotlight to direct light across the face of the sign. The light beam, as it passes over the sign face, elicits a "glow" or "flash" response from the sign if it has satisfactory retroreflectivity. Determination of a sign's reflective performance is limited to a pass/fail criteria, and with some training, an inspector can easily determine which signs are failing.

Ambient light, such as direct sunlight, can cause interpretation of the sign's "flash" response from the spotlight to be difficult. For this reason, use of spotlight intensities less than the 200,000 candle-power recommended by the Mississippi Department of Transportation is not advised. Higher intensity spotlights, such as 500,000 to 1,000,000 candle-power, aid in eliminating the detrimental effects of ambient light. This high level of spotlight intensity obtains an easily interpreted "flash" response from the reflective material, even in the worst ambient light conditions.

Phase I of this research evaluated the validity of the results of this technique as a management tool. The results from this test of the spotlight technique illustrated that results do not depend on the intensity of the spotlight, as long as the intensity is bright enough to interpret the sign response. Through experience using different spotlight intensities, it was noted that while the end results were the same, use of the higher intensity spotlights allowed for a faster and easier interpretation of the flash response, and therefore are recommend. This test clearly demonstrated the ability of the spotlight to be used effectively for the basis of a pass/fail sign performance evaluation. Use of this technique is also useful as a tool to identify signs that are in need of further inspection due to factors other than deficient retroreflectance.

Task G - Sample Procedures and Methodologies

Current MDT Procedures

To adequately assess the impact of the FHWA proposed revised retroreflectivity requirements necessitates an accurate and reliable inventory of all signs on Montana's State-maintained routes.

Currently, the Montana Department of Transportation uses a paper-based sign inventory consisting of hand-written data collection forms that are updated during maintenance activities. A sample data form that is currently the basis for the Montana sign inventory is included in Appendix A. This inventory is neither complete, nor comprehensive. For management of the inventory, there are no tools that allow prediction of sign replacement, facilitate the tracking of sign maintenance activities, or store information on the reflective condition of the signs in the inventory. MDT also has no consistent inspection procedures currently in place, such as the Mississippi DOT spotlight technique, that are designed to check the retroreflective performance of signs, and allow for replacement of signs that are not retroreflective.

Proposed FHWA Procedures

It was the recommendation of Phase I that MDT adopt the FHWA Sign Management System (SMS) software version 4.1 as the basis for future sign inventory and management needs. The FHWA Office of Safety and Traffic Operations Research and Development developed the SMS program to provide state and local highway agencies with a tool for assembling a sign inventory, and assist them in managing the inventory in accordance with the proposed guidelines on minimum retroreflective levels for traffic signs.

The SMS program integrates three basic elements for comprehensive sign management:

- Inventory - catalogue location and physical characteristics
- Inspection - assess retroreflective performance and physical condition
- Maintenance/Replacement - record maintenance activities

These basic elements provide accurate data that help determine the retroreflective condition of a sign, which is the key determinant of a sign's effectiveness. The program also includes sign deterioration models based on the sign's age and/or the sign's current retroreflectivity to predict when a sign is likely to need replacement. These models then allow the user to estimate future budget requirements for sign replacement.

The three main sections that form the operational base of the SMS program are the Sign Inventory, the Sign Dictionary, and Utilities. These are given and discussed, along with the types of SMS reports, in Appendix B. (14)

Butte District Sample Inventory

To demonstrate the capabilities of the FHWA-developed SMS, a partial inventory of highway signs on multiple State-maintained routes was compiled using the spotlight technique. As described previously, use of the spotlight technique is an effective measure of a sign's retroreflective performance, and allowed for large scale data collection efforts within the allotted time and budget constraints of the study. Table 6 summarizes the Butte District inventory sample by roadway miles, number of signs and functional classification of the roadway. (15)

Volunteer efforts of the Montana State University Student Chapter of the Institute of Transportation Engineers (ITE) made it possible to collect data throughout the entire Butte District. The Butte District was divided into 17 routes that were suitable for volunteer effort, with the remainder to be covered by research staff. Each route was assigned to a two-member team of ITE volunteers, and training on sign inventory practices was conducted to help eliminate any inconsistency in the data collection procedures. This training consisted of viewing the training video that was produced by the Mississippi Department of Transportation and a review of each data element required on the field data inventory sheets that were to be completed by hand. The field data collection form, form data field explanation and volunteer agreement are included in Appendix C. Spotlights, safety vests and hard-hats were provided for each team by the Montana Department of Transportation.

Table 6: Butte District Sample Inventory

Butte District					
Route	Total Roadway km (miles)	Total Roadway Signs	Sampled Roadway km (miles)	Sampled Roadway Signs	Roadway Functional Classification
P8	175.42 (109)	879	172 (107)	639	2
P11	91.73 (57)	600	88.5 (55)	214	2
P12	14.48 (9)	124	14.48 (9)	81	2
P13	156.11 (97)	632	156.11 (97)	468	3
P14	124.24 (77.2)	695	124.24 (77.2)	291	3
P19	43.45 (27)	443	43.45 (27)	165	3
P29	144.84 (90)	701	136.8 (85.5)	474	3
P41	32.18 (20)	81	32.18 (20)	30	3
P46	125.36 (77.9)	560	125.36 (77.9)	223	3
P47	10.94 (6.8)	58	9.6 (6)	56	3
P49	43.45 (27)	177	43.2 (27)	104	3
P50	146.13 (90.8)	836	146.13 (90.8)	492	2
P55	20.92 (13)	159	16.09 (10)	73	3
P59	92.54 (57.5)	441	91.2 (57)	177	3
P60	46.03 (28.6)	135	46.03 (28.6)	101	3
P64	14.65 (9.1)	59	14.4 (9)	59	3
P69	61.16 (38)	273	60 (37.5)	109	3
P84	46.67 (29)	226	46.67 (29)	131	3
P85	10.62 (6.6)	125	9.6 (6)	125	2
P86	60.67 (37.7)	302	60.67 (37.7)	173	3
P87	36.05 (22.4)	136	35.2 (22)	65	3
P88	2.29 (1.42)	52	1.6 (1)	52	2

	Total Roadway Miles (km)	Total Roadway Signs	Sampled Roadway Miles (km)	Number Sampled Signs
Totals:	1 499.94 (932.02)	7694	1 473.51 (917.20)	4302

Each route was approximately 120 km (75 miles), or a maximum of 320 km (200 miles) round trip, and represented a time commitment of approximately 8 hours from each of the two-person teams. Through this effort, data on sign location, condition, and spotlight reflectivity performance were collected for the non-urban, two-lane highways in the Butte District. This volunteer effort supplemented research sampling efforts, making it possible to gain full coverage of the principal arterial and minor arterial routes in the Butte District.

Future inventory data collection efforts could be aided through the use of Scantron™ data collection sheets that are set up in a format compatible with the SMS program. MDT has recently developed such a data collection system, and the Scantron™ data sheet is included in Appendix D.

Statewide Sign Retroreflectivity Sample

The measurement and collection of a complete inventory of all signs on State-maintained routes was not within the scope of this project. Therefore, to determine the reflective condition of signs throughout the State of Montana, a representative sample of signs was selected from within each District's boundaries. Each District sample represents a broad geographic area, minimizing data redundancy for the several maintenance areas within each District. Attention to sign orientation was critical, as overrepresentation of signs with southern or eastern exposure would improperly bias the sample due to solar degradation. Each District sample was then measured with the ART 920 in accordance with the procedures discussed in Task F.

Initial sampling cell designations were created using guidelines proposed by the FHWA for a study evaluating the current State of Texas sign inventory. These guidelines would have yielded a minimum of 200 sign measurements per District, and a confidence level of greater than 95% using the ART 920 retroreflectometer. This number was based on the assumption that sufficient numbers of the different size categories would be present in the field. Application of these sampling requirements in Montana proved to be too strict. Signs of different sizes were present in each District, but not to the extent that it was possible to fill the cells as outlined in the Phase I sampling schedule. Therefore, the sampling schedule was modified to be inclusive of sign sizes and sheeting grades that were actually present in the field using the general division of

sign color combinations of black on white, black on yellow, white on green, and white on red. A minimum of twenty-five (25) signs in each sample cell designation was collected in each District which produced a statistical confidence level of 90% for the sample (Table 7).

Table 7: Revised District Sampling Schedule for Non Interstate Non-Urban Two-Lane Highways

Legend Color	Background Color	Minimum Number in Sample
Black	Yellow	25
Black	White	25
White	Red	25
White	Green	25

Task H: Statewide Sampling and Inventory

Statewide Sampling

During the months of May through August of 1996, retroreflective measurements were taken in each of the five Montana Department of Transportation Districts: Butte, Missoula, Great Falls, Billings and Glendive. This statewide sampling was performed in accordance with the sample cell designations and practices discussed in Task G.

The results of this statewide sample of retroreflective readings are organized and reported for each District in graphic and tabular form. The retroreflective data for each of the five Districts are presented graphically in Figures 1 through 5. The data depicted in Figures 1 through 5 are broken down into categories determined by sign legend and background color in Tables 8 through 12 respectively. They provide a description of the overall sign condition in each District according to the proposed FHWA retroreflective guidelines. The legend terminology is Pass/Fail for clarity, and refers to the ability of the signs in the District to perform according to the revised retroreflectivity guidelines proposed by FHWA.

From this sample data, the following observations can be made:

- The condition of signs in the Butte District appear to be deficient primarily in the White/Red regulatory sign category.
- The Missoula District sample has the highest failure rate as a whole. This could be due to a variety of factors. The presence of damage and vandalism to signs in the Missoula district was noticeably higher than in other Districts, which corresponded to lower retroreflective readings in several instances. The White/Red regulatory sign failure rate is low, as the presence of new STOP signs was very common.
- The Great Falls District shows deficiencies primarily in Black/White and White/Green signs.
- The Billings District exhibits predominant deficiencies in the Black/White and White/Green sign categories.
- While deficiencies in the White/Green sign category exist, the overall sign condition in the Glendive District is excellent.

Figure 1: Butte District Estimated Sign Retroreflective Condition

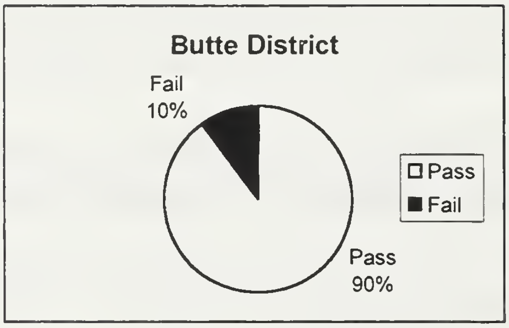

Table 8: Butte District Sample Data

Color; legend/Background	%Passing	%Failing	Total Number
Black/Yellow	94.9	5.1	39
Black/White	89.2	10.8	37
White/Green	90.6	9.4	32
White/Red	84.4	15.6	29

Figure 2: Missoula District Estimated Sign Retroreflective Condition

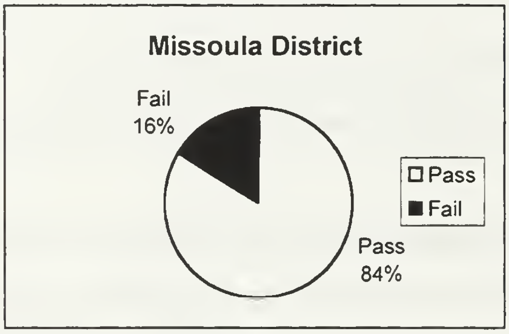

Table 9: Missoula District Sample Data

Color; legend/Background	%Passing	%Failing	Total Number
Black/Yellow	90	10	30
Black/White	72.9	27.1	48
White/Green	71	29	31
White/Red	100	0	27

Figure 3: Great Falls District Estimated Sign Retroreflective Condition

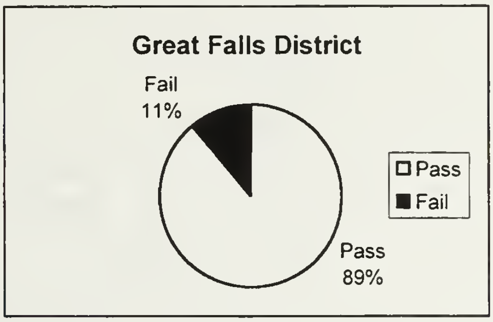

Table 10: Great Falls District Sample Data

Color; legend/Background	%Passing	%Failing	Total Number
Black/Yellow	97.4	2.6	39
Black/White	79.3	20.7	29
White/Green	84	16	25
White/Red	92.6	7.4	27

Figure 4: Billings District Estimated Sign Retroreflective Condition

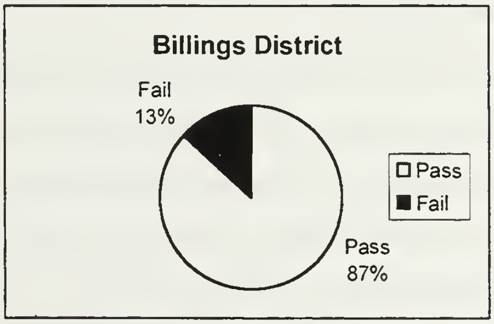

Table 11: Billings District Sample Data

Color; legend/Background	%Passing	%Failing	Total Number
Black/Yellow	97.2	2.8	36
Black/White	73.3	26.7	30
White/Green	85.2	14.8	27
White/Red	92.6	7.4	27

Figure 5: Glendive District Estimated Sign Retroreflective Condition

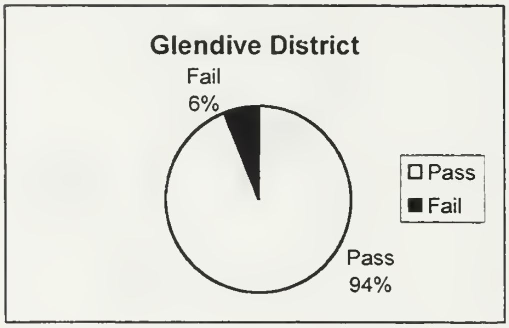

Table 12: Glendive District Sample Data

Color; legend/Background	%Passing	%Failing	Total Number
Black/Yellow	97.1	2.9	34
Black/White	96.3	3.7	27
White/Green	82.8	17.2	29
White/Red	100	0	27

Butte District Partial Inventory

As previously discussed, a partial inventory of signs in the Butte District was completed with the help of the MSU Student Chapter of ITE, which enabled a comparison of this Inventory data with the Butte District Sample data. The sample data includes signs measured with the ART 920 retroreflectometer using the sample schedule contained in Table 8. The partial inventory represents the data collected using the MDT spotlight technique, and includes non-urban, non-Interstate signs (in the direction of travel) in the Butte District. This comparison is shown in Table 13.

As indicated, there seems to be a correlation between the ART 920 sampling done in the Butte District and the partial inventory conducted throughout the Butte District, using the MDT spotlight technique.

Table 13: Butte District Partial Inventory vs. Sample Data

	Butte Sample		Butte Inventory	
Color; legend/Background	Number of Signs	% Failing	Number of Signs	% Failing
Black/Yellow	39	5.1	1,739	1.6
Black/White	37	10.8	1,376	11.55
White/Green	32	9.4	613	8.9
White/Red	29	13.8	125	15

Task I: Analyze and Summarize Field Data

By combining all District sample data, taken with the ART 920 retroreflectometer, an average value for the overall estimated non-Interstate roadway sign condition in Montana could be calculated. Figure 6 represents the percentage of signs on Montana's non-Interstate highways not meeting the proposed FHWA minimum retroreflective criteria. Table 14 details the projections for the percentage of signs on Montana's non-Interstate highways not meeting the proposed FHWA minimum retroreflective criteria, broken down by each major sign color combination.

Figure 6: Montana Non-Interstate Estimated Average Sign Retroreflective Condition

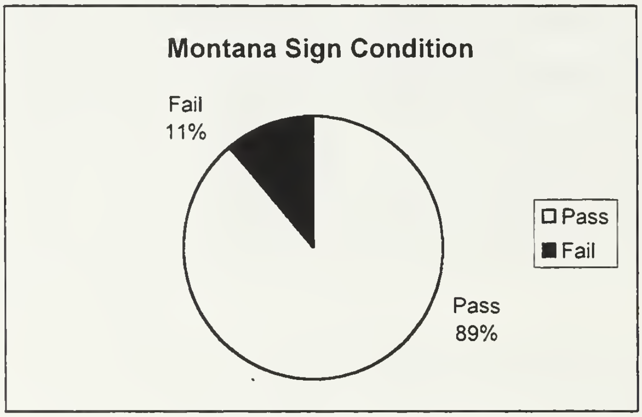

Table 14: Statewide Average Estimated Sign Condition, Rural, Two-Lane State Highways

Color: Legend/Background	Percent Failing Proposed Guidelines
Black/Yellow	3.9%
Black/White	18.7%
White/Green	17.4%
White/Red	5.8%

To establish the economic impact that highway sign replacement will have on the State of Montana, a sign representative of the sign category within each District, or design sign, was necessary for calculations. A design sign for each of the four types of signs was determined for each of the five Montana Districts. Frequency, size, and design of roadway signs from each District were weighted and averaged, resulting in a calculated design sign for each district, referred to as the composite, or composite design sign. A representative design sign was also determined for each of the four major divisions of sign types within each District, and these values are reported in Table 15. The calculation method is illustrated in Appendix E.

Table 15: Calculated Design Sign Area, meters^2 (ft^2)

District	Black/Yellow	Black/White	White/Green	White/Red	Composite
Butte	0.547 (5.89)	0.386 (4.15)	1.841 (19.82)	0.666 (7.17)	0.752 (8.09)
Missoula	0.714 (7.69)	0.465 (5.00)	1.789 (19.26)	0.694 (7.47)	1.049 (11.30)
Great Falls	.659 (7.09)	0.458(4.93)	2.688 (28.93)	0.659 (7.09)	1.024 (11.02)
Billings	0.715 (7.70)	0.588 (6.33)	2.339 (25.18)	0.656 (7.06)	1.031 (11.10)
Glendive	0.624 (6.72)	0.497 (5.35)	3.070 (33.05)	0.656 (7.06)	1.193 (12.84)

Estimates for the average cost to replace a sign vary from $53.80 per square meter ($5.00 per square foot), which represents just the retroreflective sign materials, to $156.07 per square meter ($14.50 per square foot), which includes backing materials and hardware. To use a realistic figure, projections in Tables 16 and 17 are based on a conservative $107.60 per square meter ($10.00 per square foot) estimate, as deemed reasonable for partial hardware replacement. (16)

Using the data previously presented in Tables 8 through 12, cost projections can be determined for sign replacement in each District. Information presented in Table 17 represents the costs estimated to bring all signs currently in the field up to the minimum levels of retroreflectivity proposed by the FHWA.

Replacement costs are also based on the assumption that the proposed minimum retroreflective criteria are the basis for a replacement of a sign. These proposed criteria are likely to become a guideline, and replacement of critical signs according to these guidelines is advised. However, MDT's determination of appropriate replacement criteria may have a significant effect on the dollar amounts represented in Table 17.

Table 16: Inventory Value Projection, Rural, Two-Lane State Highways

District	Total Number of Signs	Composite Design Sign Area m^2 (ft^2)	Total Sign Area m^2 (ft^2)	Replacement Cost \$/m^2 (\$/ft^2)	Total Sign Inventory Value
Butte	7,652	0.752 (8.09)	5 754.30 (61,904.68)	107.60 (10)	$619,046.80
Missoula	10,627	1.049 (11.30)	11 147.72 (120,085.10)	107.60 (10)	$1,200,851.00
Great Falls	8,134	1.024 (11.02)	8 329.22 (89,636.68)	107.60 (10)	$896,366.80
Billings	8,969	1.031 (11.10)	9 247.039 (99,555.9)	107.60 (10)	$995,559.00
Glendive	11,027	1.193 (12.84)	13 155.211 (141,586.68)	107.60 (10)	$1,415,866.80
Total: Montana	46,409	1.026 (11.05)	47 633.49 (512,769.04)	107.60 (10)	**$5,127,690.40**

Table 17: Summary of Projected Replacement Costs, Rural, Two-Lane State Highways

District	%Sampled Signs Failing Minimum Criteria	Total Number of Signs	Composite Design Sign Area m^2 (ft^2)	Estimated Failing Sign Area m^2 (ft^2)	Total Estimated Immediate Sign Replacement Cost *
Butte	8.4	7,652	0.752 (8.09)	483.095 (5,199.99)	$51,999.93
Missoula	16.2	10,627	1.049 (11.30)	1 805.93 (19,453.78)	$194,537.86
Great Falls	10.8	8,134	1.024 (11.02)	899.56 (9,680.76)	$96,807.61
Billings	12.5	8,969	1.031 (11.10)	1 155.88 (12,444.48)	$124,444.88
Glendive	6	11,027	1.193 (12.84)	789.31 (8,495.20)	$84,952.00
Total: Montana	10.9	46,409	1.015 (10.93)	5 134.76 (55,270.06)	**$552,700.60**

*Assuming $107.60 per square meter (\$10/ft^2) replacement cost

Assuming the ART 920 samples are correct indications of sign retroreflective conditions within each District, the approximate cost to bring Montana's non-Interstate sign inventory (excluding overhead signs) up to the proposed minimum retroreflective guidelines are approximately 11% of the total inventory value of **$5,127,690.40**, or approximately **$552,700.60.** The conservative nature of these projections may underestimate the value of the sign inventory, but should allow a fair estimate of the associated replacement costs.

For MDT to address the replacement of signs based on diminished retroreflective properties, an adequate sign inventory is necessary. Due to the large value of signs in MDT's inventory, use of the FHWA developed Sign Management System (SMS) 4.1 software is a valuable tool for implementing a sign inventory and monitoring sign management operations.

Data requirements for SMS 4.1 are not extensive, and will not require as much additional effort as possibly perceived. Several weeks were involved with the collection of the Butte partial inventory data. This data collection effort was only collecting data on signs in the direction of travel and in non-urban areas, but does allow for some constructive analysis of the time commitments necessary for a complete inventory effort for the State of Montana. Using the experience from the Butte District data collection efforts, the time commitment was approximately two to four minutes per sign for data collection. When including driving time and distance involved on rural routes, an average progression of 32.2 to 40.2 kilometers (20 to 25 miles) of roadway per hour (in one direction of travel) is not uncommon. These figures can be extrapolated conservatively to estimate the time commitment that will be required for these activities. Table 18 details the projections based on an average of three minutes per sign.

Table 18 assumes that the collection effort is performed by either a two-person untrained team, or an experienced single person effort. If this is performed as a general labor task, at a compensation of $20.00 per hour (plus equipment costs) of sign inventory data collection the total estimated cost is approximately $46,500, with an approximate cost to each District ranging from $8,000 to $12,000. This effort could be accomplished in a variety of ways including:

- Use of temporary or summer-hire work, using two-person teams for one full summer in each District.

- Schedule inventory data collection efforts during (or in place of) the current semi-annual visual inspection efforts within each District utilizing current maintenance staff. This would allow the effort to be distributed over a multi-year time period.

- Sub-contracting to a consultant for the purpose of collecting the entire data inventory.

Table 18: Projected Sign Inventory Time Commitment

District	Total Road Kilometers (miles)*	Total Signs*	Average Signs per Kilometer*	Average Time per Sign*	Estimated Total Time*
Butte	1 513.94 (940.72)	7,652	5.05	3 min.	382.60 hrs.
Missoula	1 801.90 (1,119.65)	10,627	5.89	3 min.	531.35 hrs.
Great Falls	1 422.58 (883.95)	8,134	5.72	3 min.	406.70 hrs.
Billings	1 468.22 (912.31)	8,969	6.11	3 min.	448.45 hrs.
Glendive	2 756.79 (1,712.99)	11,027	4.00	3 min.	551.35 hrs.
Totals	8 963.43 (5,569.62)	46,409	5.18	3 min.	**2320.45 hrs.**

*Non Interstate, on-system (15)

Financially, replacement of all signs that are retroreflectively deficient may be a large burden. To address the failing percentage of signs within each district, options for sign replacement strategies may be investigated for financial feasibility. Optional sign replacement strategies are varied in both form and warranting criteria. Several strategies to be considered are:

1. Targeted replacement by inspection failure and/or as needed due to vandalism, theft, collisions, etc.;

2. Retroreflectivity inspection assessment for projected failure replacement;

3. Age inventory with replacement at a projected life; and/or

4. Scheduled replacement of all signs by category type over a designated multi-year period, i.e. 5, 7, or 10 years.

Task J: Summary of Findings

The objective for Phase II of this study was to conduct a state-wide sampling, by MDT District, of all current traffic sings on the State Highway system. This sampling allowed analysis of Montana's sign condition in each District, and as a whole. These projections also allowed an estimate to be made for the sign inventory value, and projected cost of replacement for signs that do not possess sufficient retroreflectivity. Strategies and priorities for inventory and replacement programs are also part of the recommendations. Findings for project tasks are as follows:

- **Task F - Procure/Test Retroreflectometer Equipment:** As stated in Task I, several feasible options exist for the task of data collection within each District. Due to the time consuming and sometimes difficult nature of the ART 920 retroreflectometer, a tool for safe, efficient, and practical data collection was needed. Within Phase I of this report, a modified spotlight technique was developed and tested. This procedure allows cost effective and efficient analysis of sign retroreflective performance based on a pass/fail criteria. FHWA has developed a mobile Traffic Sign Evaluator (TSE). The TSE is designed to allow safe, efficient, and accurate retroreflective evaluation of signs. The TSE should be available in the summer of 1997, and operational testing of the FHWA Traffic Sign Evaluator in Montana is highly recommended.

  Use of the ART 920 hand-held portable retroreflectometer was used to obtain retroreflective measurements on the highway signs in the District samples. The advantages to this retroreflectometer for field measurement include consistent numerical measurement of the sign face materials. Disadvantages include difficulty in obtaining readings on overhead or high mounted signs, and the time consuming nature of taking measurements.

  Within Phase I of this report, a modified spotlight technique was developed and tested. This procedure allows cost effective and efficient analysis of sign retroreflective performance based on a pass/fail criteria. This technique was successfully used by MSU ITE student chapter members to collect the Butte District inventory data.

- **Task G - Sample Procedures and Methodologies:** For MDT to address the replacement of signs based on retroreflectivity, a complete and accurate sign inventory is necessary. Current sign inventory data used by MDT is not accurate or complete. The FHWA developed SMS 4.1 software program allows comprehensive management and maintenance of sign Inventory data. MDT's adoption and support of the SMS software version 4.1 is the first step toward the successful implementation of a comprehensive sign management system that integrates maintenance operations, inventory management, and financial planning. The next step is to complete the data collection efforts, and establish an accurate and complete inventory.

  With the help of the MSU student chapter of ITE, inventory data was collected throughout the Butte District. This data collected from the Butte District was entered into the SMS 4.1 program, creating the basis for a complete inventory of these signs, and demonstrating the capabilities and practicality of the SMS 4.1 software program.

  Based upon the retroreflective sampling performed in the Butte District with the ART 920 retroreflectometer, a sampling schedule for the remaining MDT Districts was selected to represent each of the four sign color combinations. This schedule was the basis for the retroreflective measurement sampling from within each of the five MDT Districts. Analysis of this data is contained in Task H.

- **Task H - Statewide Sampling and Inventory:** As shown in Figures 1 through 5, and Tables 8 through 12, projected District compliance with the proposed retroreflective guidelines is very good. Only one MDT District (Missoula) was at slight variance (84%) with the desirable range (85-90%) originally targeted by FHWA. None of the five MDT Districts exhibited compliance problems with red regulatory signs, and no serious deficiencies exist in any sign category.

  Comparison of the Butte District sample data as measured with the retroreflectometer, to the Butte District partial inventory as collected using the MDT spotlight technique is shown in Table 13. This table demonstrates the correlation, and further validates the MDT spotlight assessment technique.

- **Task I - Analyze and Summarize Field Data:** The projected retroreflective condition of Montana's signs as shown in Figure 6 and Table 14, reveals that the composite statewide average compliance (passing) percentage of existing sampled traffic signs was 89%, and is well within the desirable range (85-90%) originally targeted by FHWA.

  Calculation of a representative design sign area was necessary to adequately assess the economic value of the sign inventory and impact of projected sign replacement within each of the five MDT Districts. These calculations are detailed in Appendix E, and the resulting inventory value projections are contained in Table 16. Projected replacement costs for each MDT District are summarized in Table 17. Projected time commitments for each MDT District are reported in Table 18. Several options are outlined for sign replacement strategies.

  Data collection to complete the sign inventory data base will take a considerable amount of time, and several options for data collection efforts are available to MDT. Projected time commitments for sign inventory data collection efforts within each MDT District are contained in Table 18.

As stated previously, one stimulus for this study has been the pending Federal Highway Administration efforts to include in the Manual on Uniform Traffic Control Devices requirements (standards) for minimum retroreflectivity values for traffic signs placed on U.S. streets and highways. Since the initiation of this project, reaction by many states to the consequences of implementation has generated further analysis and consideration by the U.S. Department of Transportation.

Recent discussions by project staff with members of both the MUTCD national committee and the FHWA Office of Highway Safety indicate several important revisions may be made to the originally proposed retroreflectivity values and implementation strategy. (17) In response to State concerns, FHWA sampled signs in various states, counties, and cities nationwide, based upon the proposed requirements. The results of that survey indicated less than desirable (<85%) conformance capability by numerous agencies. Conformance with the

proposed minimum retroreflectivity values was especially poor for red regulatory roadway signs. To enable a more reasonable level of conformance by existing sign inventories and to lessen the immediate replacement impact, it appears that FHWA has slightly reduced their proposed minimum retroreflectivity values for all sign colors except red, which was lowered substantially in comparison.

Due to the cost and labor intensive nature of conducting actual measurements of individual sign reflectivity with currently available equipment, FHWA will probably not require actual measured values to establish compliance or failure. Regular visual inspections utilizing normal assessment procedures will be acceptable. Furthermore, all overhead signs will be exempt from the proposed minimum retroreflectivity requirements.

The rule-making language to be put forth by FHWA regarding the proposed minimum retroreflectivity values for traffic signs will be structured in terms of "guidelines", rather than mandated "standards". This will allow Transportation agencies of jurisdiction more discretion in their decisions regarding sign replacements for conformance with FHWA recommendations.

Task K: Training and Implementation

Training for implementation of the FHWA Sign Management System was conducted for the Montana Department of Transportation by project research in October, 1996. The following MDT personnel were in attendance:

- Mr. Pat Brannon, Maintenance
- Mr. Jim Cornell, Traffic
- Mr. Skip Nyberg, Information Services Bureau

Training assistance was also provided by Mr. Steve Jenkins, Director of the Local Technical Assistance Program (LTAP).

The purpose of this training was to address the technical aspects of SMS operations, program file organization, functions within the program, and to respond to concerns that MDT has about the program. Training was organized around the operational format of the SMS program software version 4.1. The training outline, as presented, is included in Appendix E. This outline details the organizational structure of file operations and allowed for a structured discussion of the program's functional capabilities and limitations.

Both during and after the session, questions were raised about several issues surrounding the SMS program and its implementation. A brief summary of these discussions follows, with the question or issues in *italics*, and the response in standard print.

Some District Administrators (DA's) have voiced the concern that the cost of establishing a sign management system will be too costly and therefore impractical. They feel that the added cost

and effort of collecting the sign inventory data will be too much of an added burden to already busy field personnel. How can the use of this sign management system format, SMS 4.1 benefit these people, and what arguments are there to address these concerns?

This is a very complex question and should be addressed in several ways. First, as previously discussed in Task I, the establishment of a sign inventory is feasible at a manageable cost in a reasonable period of time by several different implementation strategies.

Second, the costs associated with the SMS should not be thought of as additional. This program will help maintenance personnel with their everyday operations. For the first time, each District will know what signs are where, will be able to identify problem locations, and will be able to easily and consistently locate down, broken, damaged, or missing signs. Several people only associate the benefits of a comprehensive sign management system with the issue of liability. While this is a very large benefit of any sign management system, it is not the only or even the primary focus of the system. The sign management system, as the organization of the SMS 4.1 program will attest, is designed to manage the inventory of signs in a given jurisdiction. It enables a manager to predict sign replacement through a variety of performance measures, and make sound decisions regarding planning and budgeting for future needs. It also allows the manager to determine how to best establish replacement priorities, as the information is complete and accurate, something that is currently a rare luxury to many concerned with the inventory of signs.

The value of a SMS program to Montana is immeasurable when it comes to the rebuttal and defense of tort claims. Responsibility for a physical inventory of signs worth several million dollars is not a small task. With this unavoidable responsibility comes liability for those signs. Montana can adequately address this issue through a management system for this inventory.

Several of the signs Montana commonly uses are not contained in the SMS sign dictionary, how can this be changed?

The SMS 4.1 program enables the addition of signs into the dictionary. The standard sizes, shape, color combination for background and legend, and MUTCD code are all data fields that are included in this procedure. This feature also allows the use of special codes for signs

to Montana. The final SMS program from FHWA will have an expanded dictionary supplied within the format of the program.

If MDT opts to use the Scantron form, will they be compatible with the SMS program? Also, MDT has contracted for a sign inventory database to be created using a different software program than SMS. How compatible is SMS with other data formats, and will FHWA release the source code, and/or support this program?

SMS is a program that needs the data ordered in a certain format to be accepted into the database. Some modification to the data format obtained through the Scantron forms may be necessary, but Research staff has been assured by MSU systems support personnel that this would be a fairly simple operation. SMS is a database oriented program that contains unique predictive modeling capabilities for sign replacement based on retroreflective values. Other software programs will not supply this ability. The data collected through the use of other software packages could be converted into a SMS compatible file format, and used to update the database.

A current and accurate sign inventory for the purposes of proper maintenance, management, and budgeting activities is imperative. MDT's commitment to developing and maintaining this inventory is the first important step to better sign management. Data management will be greatly enhanced and facilitated through the use of software such as the SMS version 4.1 program.

Recommendations

The Montana Department of Transportation has already engaged in a major effort to upgrade the quality of face sheeting (and resulting retroreflectivity) of all Interstate route signs in Montana. It is the recommendation of the research study staff that MDT strongly consider a similar multi-year upgrading of all signs on non-Interstate, State maintained roadways in Montana.

Many states faced with considerable sign replacement and maintenance costs to meet the proposed FHWA retroreflectivity values have elected to upgrade their traffic sign systems to full compliance, regardless of whether these requirements are mandated or not. Their justification for this policy decision is based upon the need for high quality nighttime visibility of all traffic signs due to the increased elderly driving population or to offset the debilitating effects of either adverse weather or vandalism.

This replacement strategy could be implemented on an "as needed" or scheduled percentage basis to be fully completed in a five to ten year time period depending on budget allocation and whether this is handled by MDT maintenance personnel or an independent contractor. Estimates of immediate replacement costs for existing traffic signs not meeting the proposed FHWA retroreflectivity values, were previously given. Subsequent replacement due to age, weather, vehicular impacts, and vandalism would be similar.

As noted in Phase I of this study, MDT currently has not adopted any consistent or effective policy or procedures related to sign inventory or management. The recommendation of the research study staff is for MDT administration to support the adoption and implementation of the FHWA Sign Management System software in conjunction with appropriate manual sign inventory data collection methods. Sign data collection forms and methodology were previously discussed in this report and demonstrated in the Butte District. Program utility and initial MDT staff training has also been conducted.

Recommendation for the acquisition of SMS software is based upon the following:

(1) Federal expenditure for program development and support;

(2) Continued FHWA training and support for implementation;

(3) Agency access to software at no cost;

(4) Program utility for production of sign management reports;

(5) Predictive capability with age and retroreflectivity algorithms; and

(6) Expertise and support through Montana State University Local Technical Assistance Program.

Initially, thirty years ago, Highway Safety Standard 13, "Traffic Engineering Services" in the Highway Safety Act of 1966, required each state and its political subdivisions to have a traffic control device program.(18) The safety standard stated that a traffic control devices plan should include:

- An inventory of all traffic control devices; and
- A periodic review of existing traffic control devices, including a systematic upgrading of substandard devices to conform with standards issued or endorsed by the FHWA.

While the Highway Safety Standards have been revised extensively with the passage of subsequent Surface Transportation Acts, the mandate for properly installed and maintained traffic control devices documented through an inventory program has not been lessened.

Many agencies maintain sign inventory data as part and parcel of their overall management effort. Some agencies emphasize the importance of sign inventory as a risk management tool for tort liability defense. A study in Iowa (19) recommended the establishment of a continuing sign inventory process and emphasized:

> "A sign inventory is essential to provide evidence of the existence of a particular sign in a particular location at a specific time. It also provides a convenient mechanism for evaluating sign usage for conformance with standards. The inventory process should be continuous with constant updating as signs are added, removed, or replaced."

An effective and accurate sign inventory is key to not only targeting signs for replacement due to age, weather and so forth, but provides the necessary information for decisions relative to:

- Identification of any and all deficient signs;
- Development of maintenance needs priorities;
- Scheduling of maintenance resources;
- Overall system planning and budgeting;
- Continued surveillance of maintenance activities; and
- Tort liability defense.

In summary, improving the nighttime visibility and communication capability of roadway signs in Montana is justified and appropriate. It appears that this can be done in a effective and cost feasible manner over a multi-year period by establishing an accurate sign inventory and utilizing the Sign Management System computer software.

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Appendix A: MDT Sign Inventory Form

SURVEY BY CREW ______ RURAL ______ URBAN ______ DIVISION

DIRECTION DATE TIME

ROUTE NUMBER	MILE POST	TYPE SIGN	SIZE		CORRECTIVE ACTION NEEDED		CONDITION/REMARKS/LEGEND
			HORIZ.	VERT.	REPLACE	OVERLAY	

Appendix B: SMS Review and Sample Report Output

Sign Management System

The three main sections that form the operational base of the SMS program are the Sign Inventory, the Sign Dictionary, and Utilities.

SMS Sign Inventory. The SMS program requires that certain data elements be identified for each sign. Each sign in the inventory is treated as a separate sign record, and should contain as much information as possible on the sign's age, color, location, type, and other information as is available. Several data elements in the program are optional, or can be defined by the user to customize the program function to the specific needs of the user. Required data elements are as follows:

- Route Name/# - maximum of 25 characters, i.e. US 191
- Location - three options as described later, i.e. mile point 23.4
- Direction - compass direction of travel, i.e. N, S, E, W
- Position - location of sign relative to road, i.e. Right (R) or Left (L)
- Orientation - direction the sign is facing, i.e. N, S, E, W, NW,NE, SE, SW
- MUTCD - sign type code, i.e. R1-1
- Sheeting - type of reflective sheeting, i.e. EG or HI
- Install Date - date of installation of sign, i.e. 05/27/95

As indicated, three methods of sign location measurement are available in SMS. The first option is the milepoint location method which may be used if the road is referenced by milepoint. The location of the sign along the road can be entered to the nearest 0.001 mile. The second option is the intersection/distance location method. This method may be used to reference the sign location to the nearest intersection or to any other prominent feature. The distance from the feature is entered in feet. This option requires the name of the intersection to be entered in the "INTERSECT" data field. The third option, the milepost method, is advantageous when there are mile markers on the roadside. Distance can be measured to the nearest 0.1 mile. The closest mile marker is entered, with the distance from the mile marker to the sign recorded as a plus sign (+) if referring to a sign that is located after the mile marker and a minus sign (-) if referring to the distance a sign is located before a marker.

A history file is created to track the inspections of each sign record in an inventory file. A history file is unique to each inventory file, as it keeps track of all the inspection data for the signs in that specific file. This file is updated automatically each time a new inspection date is entered. Additionally, the condition of the sign at the time of inspection can be entered and the measured R_A recorded. This file is important in tracking a sign's deterioration throughout its existence, and is used in the Utilities section of the SMS program. It also helps keep track of sign maintenance activity.

An archive file is built when the user creates an active inventory file. Each archive file contains all of the current active sign records. The archive file is a storage file used when active signs are removed from service. To archive a record, the user moves it from the active file to the archive file. All of the data previously entered into the active sign record will remain unchanged in the archive file because archive files may be accessed, but not modified. This file stores the removal date and reason for removal of the sign.

SMS Sign Dictionary. The sign dictionary is the data file where the majority of the information on sign codes, as outlined in the Manual on Uniform Traffic Control Devices (MUTCD), is contained. These signs are referenced from the sign inventory records, and signs not contained in this dictionary may be entered as separate entries, customizing the dictionary files.

The sign dictionary is also the file location where cost estimation data are located. Estimated cost per square foot for most of the signs in the dictionary is included with the program. For those signs that don't have replacement costs provided, average replacement costs can be entered by the SMS user. Summary costs for each sign are presented in the inventory file.

SMS Utilities. Contained within SMS is a test sign program that is designed to allow a user to refine the deterioration equations to better model the conditions in a particular geographic area. This program involves selecting a sufficient sample of signs that are in the field, periodic measurement of these signs R_A, data analysis, equation modification and verification of results.

The user manual supplied with the SMS fully describes procedures to correctly conduct this test sign program. The default equations contained in the program are sufficient for most locations.

The capability of SMS to predict the replacement date of signs by means of deterioration models is limited to sheeting Type I (engineering grade) and sheeting Type IV (high-intensity). Using eight possible sheeting/color combinations, derived from the four possible sign colors (i.e. red, yellow, green, and white) and the two sheeting types, SMS calculates deterioration using a regression equation for each particular combination. From this calculation, SMS then estimates the replacement date for any given sign.

SMS Reports

The SMS software version 4.1 program is designed to produce several types of reports for the analysis of the inventory of signs contained within the program. The several report types facilitate isolation of certain parameters for further analysis. The types of reports included in the SMS consist of the following:

- General Inventory - Selection criteria for this report will determine the format for the data representation. Route/Location will order the report by route name and by method of measurement/location reference in numeric order. Route/ID# will order the report format by route name and by ID# in ascending order. This report will detail all recorded information on each sign in the file.
- Inspection History - This report contains inspection information for those signs which meet the selection criteria, as specified by the user.
- Backing - This report contains backing information for an active file including backing type, shape, size, and quantity.
- Sheeting - This report details the types and quantities of sheeting within the active file, specified by legend, size, and MUTCD code.
- Face - This report details the sheeting type, legend and background colors, sign shapes, sign sizes, and quantities within the active file.

A complete example of all the major SMS report types are given as follows.

SIGN INVENTORY REPORT

Route XX

SORTED BY : Route/Location (with comments) (with legend)

Search criteria:

Route Name/# : MT48

ID#	INTERSECTION	DIR/ MILEPOINT	MUTCD ORIEN	USER CODE	SIZE DEF	W	H	INSPECT SHEET	MSRD Ra BACK	REPL DATE	L	B	CON	ACT DATE	RPL COST

ROUTE NAME: MT48

1 0.000 N/S R4-7 GOOD 24 30 EG A 09/07/96 G 11/2010 25

Legend: KEEP RIGHT

55 0.000 W/NE R1-1 GOOD 36 36 EG A 09/07/96 E 03/2010 45

Legend: "STOP"

53 0.020 W/NE M1-5A GOOD 24 24 EG A 09/07/96 G 11/2010 30

Legend: "[1] STATE ROUTE MARKER

54 0.020 W/NE M6-4 GOOD 21 15 EG A 09/07/96 G 11/2010 11

Legend: " < --/-- > " ARROWS

52 0.030 W/NE R4-7 GOOD 24 30 EG A 09/07/96 G 11/2010 25

Legend: KEEP RIGHT

51 0.050 W/NE R6-3A GOOD 24 18 EG A 09/07/96 G 11/2010 15

Legend: "DIVIDED HIGHWAY" T-INTERSECTION

50 0.080 W/NE M2-1 GOOD 21 15 EG A 09/07/96 G 11/2010 11

Legend: "JCT"

56 0.080 W/NE M1-5A GOOD 24 24 EG A 09/07/96 G 11/2010 30

Legend: "[1] STATE ROUTE MARKER

2 0.100 N/S M3-1 GOOD 24 12 EG A 09/07/96 G 11/2010 10

Legend: "NORTH"

3 0.100 N/S M1-5A GOOD 24 24 EG A 09/07/96 G 11/2010 30

Legend: "[##] STATE ROUTE MARKER

49 0.100 W/NE D1-2 GOOD 120 60 EG A 09/07/96 G 05/2011 250

Legend: [TWO DEST.] W/ARROWS

4 0.110 N/S D2-1 GOOD 24 18 EG A 09/07/96 E 03/2008 15

Legend: [DESTINATION] W/[##] MILEAGE

5 0.200 N/S M2-1 GOOD 21 15 EG A 09/07/96 G 02/2008 11

Legend: "JCT"

6 0.200 N/S M1-X4 GOOD 24 24 EG A 09/07/96 G 02/2008 20

Comments: SECONDARY 273

Legend: ROUTE MARKER

47 0.200 W/NE 0000 GOOD 36 36 EG A 09/07/96 G 12/2009 45

Legend: DIVIDED HIGHWAY W/MERIDIAN

48 0.200 W/NE 0000 GOOD 24 18 EG A 09/07/96 12/2009 15

Legend: "DIVIDED HIGHWAY" PLAQUE

7 0.250 N/S M1-X4 GOOD 24 24 EG A 09/07/96 G 02/2008 20

Comments: SECONDARY 273

Legend: ROUTE MARKER

BACKING ORDER

Route XX

BACKING	SHAPE	SIZE	QUANTITY
	RECTANGLE	21" x 15"	1
A	DIAMOND	30" x 30"	1
A	DIAMOND	36" x 36"	1
A	DIAMOND	30" x 30"	1
A	DIAMOND	36" x 36"	6
A	DIAMOND	48" x 48"	1
A	RECTANGLE	144" x 60"	1
A	RECTANGLE	18" x 24"	1
A	RECTANGLE	21" x 15"	15
A	RECTANGLE	24" x 12"	5
A	RECTANGLE	24" x 24"	4
A	RECTANGLE	24" x 30"	6
A	RECTANGLE	72" x 42"	1
A	SQUARE	24" x 24"	23
P	RECTANGLE	120" x 30"	1
P	RECTANGLE	120" x 36"	1
P	RECTANGLE	144" x 36"	3
P	RECTANGLE	144" x 48"	4
P	RECTANGLE	24" x 12"	1
P	RECTANGLE	36" x 18"	2
P	RECTANGLE	36" x 24"	2
P	RECTANGLE	48" x 12"	2
P	RECTANGLE	48" x 24"	3
P	RECTANGLE	60" x 48"	1
P	RECTANGLE	72" x 36"	1
P	SQUARE	24" x 24"	2
P	VARIED	36" x 24"	1

TOTAL RECORDS : 91

FACE ORDER

Route XX

SHEETING	COLORS LEGEND	BACK	SHAPE	SIZE	QUANTITY
EG	BLACK	WHITE	RECTANGLE	21" x 15"	1
EG	BLACK	WHITE	RECTANGLE	24" x 30"	2
EG	BLACK	WHITE	RECTANGLE	24" x 30"	7
EG	BLACK	WHITE	SQUARE	24" x 18"	1
EG	BLACK	WHITE	SQUARE	24" x 24"	1
EG	BLACK	WHITE	SQUARE	24" x 24"	1
EG	BLACK	YELLOW	DIAMOND	30" x 30"	2
EG	BLACK	YELLOW	DIAMOND	30" x 30"	3
EG	BLACK	YELLOW	DIAMOND	30" x 30"	1
EG	BLACK	YELLOW	DIAMOND	30" x 30"	2
EG	BLACK	YELLOW	DIAMOND	36" x 36"	1
EG	BLACK	YELLOW	DIAMOND	36" x 36"	4
EG	BLACK	YELLOW	DIAMOND	36" x 36"	1
EG	BLACK	YELLOW	RECTANGLE	24" x 18"	2
EG	BLACK	YELLOW	RECTANGLE	24" x 18"	2
EG	BLACK	YELLOW	RECTANGLE	24" x 18"	2
EG	BLACK	YELLOW	RECTANGLE	24" x 18"	1
EG	BLACK	YELLOW	TRIANGLE	48" x 36"	51
EG	VARIED	VARIED	VARIED	120" x 24"	1
EG	VARIED	VARIED	VARIED	120" x 48"	1
EG	VARIED	VARIED	VARIED	21" x 30"	1
EG	VARIED	VARIED	VARIED	24" x 30"	1
EG	WHITE	BLUE	RECTANGLE	24" x 24"	1
EG	WHITE	BLUE	RECTANGLE	60" x 36"	1
EG	WHITE	GREEN	RECTANGLE	138" x 36"	1
EG	WHITE	GREEN	RECTANGLE	24" x 18"	1
EG	WHITE	GREEN	RECTANGLE	30" x 18"	1
EG	WHITE	GREEN	RECTANGLE	36" x 18"	1
EG	WHITE	GREEN	RECTANGLE	48" x 24"	2
EG	WHITE	GREEN	RECTANGLE	54" x 18"	2
EG	WHITE	GREEN	RECTANGLE	60" x 18"	2
EG	WHITE	GREEN	RECTANGLE	72" x 24"	1
EG	WHITE	GREEN	RECTANGLE	90" x 24"	1
HP	WHITE	BLACK	SQUARE	24" x 24"	1

TOTAL RECORDS : 104

09/28/96 SIGN MATERIALS REPORT

SHEETING ORDER

Route XX

MUTCD	SIZE	SHEETING	LEGEND	QUANTITY
0000	36" x 24"	EG	"UNIQUE TO LOCATION"	1
D1-2	144" x 48"	EG	[TWO DEST.] W/ARROWS	3
D1-2	60" x 48"	EG	[TWO DEST.] W/ARROWS	1
D1-3	72" x 42"	EG	[THREE DEST.] W/ARROWS	1
D1-X4	48" x 12"	EG	"AIRPORT" W/ARROW	2
D2-2	120" x 30"	EG	[TWO DEST.] W/[##] MILEAGE	1
D2-2	120" x 36"	EG	[TWO DEST.] W/[##] MILEAGE	1
D2-2	144" x 36"	EG	[TWO DEST.] W/[##] MILEAGE	3
D2-2	144" x 60"	EG	[TWO DEST.] W/[##] MILEAGE	1
D2-2	72" x 36"	EG	[TWO DEST.] W/[##] MILEAGE	1
D2-3	144" x 48"	EG	[THREE DEST.] W/[##] MILEAGE	1
I2-5	48" x 24"	EG	GUIDE SIGN	2
I3-1	36" x 18"	EG	GUIDE SIGN	2
I3-1	36" x 24"	EG	GUIDE SIGN	2
I3-1	48" x 24"	EG	GUIDE SIGN	1
M1-4	24" x 24"	EG	"[##] U.S. ROUTE MARKER"	19
M1-X4	24" x 24"	EG	ROUTE MARKER	4
M2-1	21" x 15"	EG	"JCT"	4
M3-1	24" x 12"	EG	"NORTH"	1
M3-2	24" x 12"	EG	"EAST"	2
M3-3	24" x 12"	EG	"SOUTH"	1
M3-4	24" x 12"	EG	"WEST"	2
M5-1(L)	21" x 15"	EG	ADVANCE LEFT TURN ARROW	1
M5-2	21" x 15"	EG	ADVANCE TURN ARROW	1
M6-1	21" x 15"	EG	"-->" DIRECTIONAL ARROW	3
M6-2(L)	21" x 15"	EG	DIRECTIONAL ARROW	1
M6-3	21" x 15"	EG	DIRECTIONAL ARROW "^"	5
M6-6(L)	21" x 15"	EG	DOUBLE DIRECTIONAL ARROWS	1
R2-1	24" x 30"	EG	"SPEED LIMIT [##]"	6
R2-2	24" x 24"	EG	"TRUCKS [##]"	3
R2-3	24" x 24"	EG	"NIGHT [##]"	3
R2-26A	18" x 24"	EG	"SPEED CHECKED BY RADAR"	1
W1-2L	36" x 36"	EG	CURVE LEFT ARROW	2
W1-2R	48" x 48"	EG	CURVE RIGHT ARROW	1
W2-2	36" x 36"	EG	SIDE ROAD (90 DEGREE)	3
W5-1	36" x 36"	EG	"ROAD NARROWS"	1
W11-4	30" x 30"	EG	CATTLE CROSSING	1
W14-X1	30" x 30"	EG	FALLEN ROCK	1
W14-X1	36" x 36"	EG	FALLEN ROCK	1

TOTAL RECORDS : 91

Appendix C: MSU SMS Data Collection Form

Team Members____

Date:______________

Location:

Route Name/Route #____________ Milepoint________________________

Direction_____________________ Position: (circle one) R L Median Overhead

Orientation (circle one) N S E W NE NW SE SW

Spotlight Reading: (circle one) Good Bad

DATA:

MUTCD Code_________________ Legend____________________________

Size: W__________H___________

Sheeting (circle one) EG HI Other

Backing: Aluminum Plywood Other

Post: Wood Metal

Complexity: Hi Med. Low Speed____________________mph

Condition: EX Good Fair Poor Replace

Install Date____________________

Offset________________________ Height_____________________________

Maintenance Required____

Comments____

____

____

____

____

Explanation for Sign Inventory Data Collection Sheets

Route Name/Route # - Highway designation; i.e. Hwy 12, US 2, MT 287, etc.

Mile point - Milepost (last+distance). Use your Odometer.

Direction - Direction you are facing when looking at the sign.

Position - Side of road the sign is on, or where the sign is located.

Orientation - Direction the sign faces

Spotlight Reading - Does it light up/flash/glow?

MUTCD Code - From Charts

Legend - What sign says; i.e. STOP, Bozeman 12, etc.

Size - Measure it (in inches)

Sheeting - Hex pattern = HI, No pattern = EG, other = other

Complexity - Your impression of how visually complex/cluttered the roadway environment is.

Condition - Can you read it? Is it bent, scraped, etc.?

Install Date - Sticker on back of sign

Offset - Normally 12 ft. horizontal, 7 ft. Vertical

MSU-ITE Student Chapter
Sign Inventory Project

I, as a member of the MSU-ITE Student Chapter, agree to serve as a volunteer to assist the Montana Department of Transportation in the inventory of highway signs on the State roadway system. This activity will consist of the following:

(1) Within a designated two-week period, provide a minimum of eight (8) hours of volunteer effort directed to the collection of specified information concerning highway signs existing on an assigned roadway route not exceeding a maximum length of seventy-five miles;

(2) This sign inventory will be conducted following both detailed technical and safety procedures for which instruction will be given. All necessary equipment, except transportation, will be provided by the Montana Department of Transportation;

(3) This sign inventory will be conducted utilizing two-person teams with reliable and safe vehicular transportation provided by one team member. A statement of in-force liability insurance will be required;

(4) Compensation to each volunteer team will consist of $30.00 per eight (8) hour assignment; $5.00 each for lunch plus $20.00 payment for transportation expense. This compensation will be requested by voucher submittal by the MSU-ITE Student Chapter;

(5) At all times during the conduct of this sign inventory, volunteers will perform work activities in a safe, reasonable, and prudent manner not to place themselves or other motorists at risk of harm. Instructions in this regard will be given prior to work commencement;

(6) At all times during the conduct of sign inventory activities, volunteers must wear MDT-supplied safety vests and hard hats when out of vehicle. At no time during the conduct of sign inventory activities will vehicles be stopped or parked without hazard warning lights engaged nor encroaching in any way upon the thru travel way;

(7) All data collected associated with the sign inventory will be turned over to Dr. John Mounce to be assimilated and analyzed subsequently for the Montana Department of Transportation; and

(8) Any questions or problems associated with the conduct of sign inventory activities will be directed to Dr. John Mounce - (406) 994-1770 or (406) 222-3726.

The aforementioned activities have been explained and discussed with me. I have also received detailed instruction regarding the following:

- Sign Inventory Forms
- MUTCD Sign Categories
- Retroreflectivity "Spotlight" Assessment
- Route Location Assignment
- Work Days/Hours
- Stopping/Parking Procedures
- Safety Vests/Hats
- Traffic Awareness
- Emergency Notification
- Compensation
- Auto Liability Insurance

Please initial each instruction item in acknowledgment as completed.

By signature below, I, as a member of the MSU-ITE Student Chapter, agree to obey and abide by all laws and regulations of the State of Montana while involved in this volunteer effort. I agree to indemnify and hold harmless the Montana Department of Transportation and Montana State University and its employees from all liability, judgments, costs, expenses, and claims of any nature whatsoever arising out of the performance or non-performance of my designated volunteer work.

______________________________ Signature

______________________________ Date

______________________________ Name

______________________________ Address

______________________________ Telephone Number

Appendix D: Scantron Data Collection Form

I	0	0	0	0
P	1	1	1	1
S	2	2	2	2
U	3	3	3	3
X	4	4	4	4
	5	5	5	5
	6	6	6	6
	7	7	7	7
	8	8	8	8
	9	9	9	9

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

- Missoula
- Kalispell
- Butte
- Bozeman
- Great Falls
- Havre
- Glendive
- Wolf Point
- Miles City
- Billings
- Lewistown

- I Interstate
- P Primary
- S Secondary
- U Urban
- X Local

COMMENTS

DIRECTION

- Northbound
- Southbound
- Eastbound
- Westbound

LANES

- 1
- 3
- 2
- 4

BACKGROUND COLOR

- White
- Green
- Yellow
- Brown
- Red
- Black
- Blue
- Orange

LEGEND COLOR

- White
- Black
- Red
- Green
- Blue

SIGN HEIGHT

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

SIGN WIDTH

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

MOUNTING HEIGHT

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

SIA

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

LATERAL OFFSET

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

INSTALLATION DATE

JAN	0	0	80	94
FEB	1	1	81	95
MAR	2	2	82	96
APR	3	3	83	97
MAY		4	84	98
JUN		5	85	99
JUL		6	86	00
AUG		7	87	01
SEP		8	88	02
OCT		9	89	03
NOV			90	04
DEC			91	05
			92	06
			93	07

POSITION

- R
- L
- O
- M

ORIENTATION

- N
- S
- E
- W
- NE
- NW
- SE
- SW

SHAPE

- Rectangle
- Square
- Diamond
- Octagon
- Triangle
- Pentagon
- Shield
- Pennant

CONDITION

- Excellent
- Good
- Fair
- Poor
- Replace

INSPECTION DATE

JAN	0	0	0	0
FEB	1	1	1	1
MAR	2	2	2	2
APR	3	3	3	3
MAY		4	4	4
JUN		5	5	5
JUL		6	6	6
AUG		7	7	7
SEP		8	8	8
OCT		9	9	9
NOV				
DEC				

SYMBOL

- Y
- N
- P

POST TYPE

- Steel
- Wood
- Breakaway
- Non-breakaway
- Other

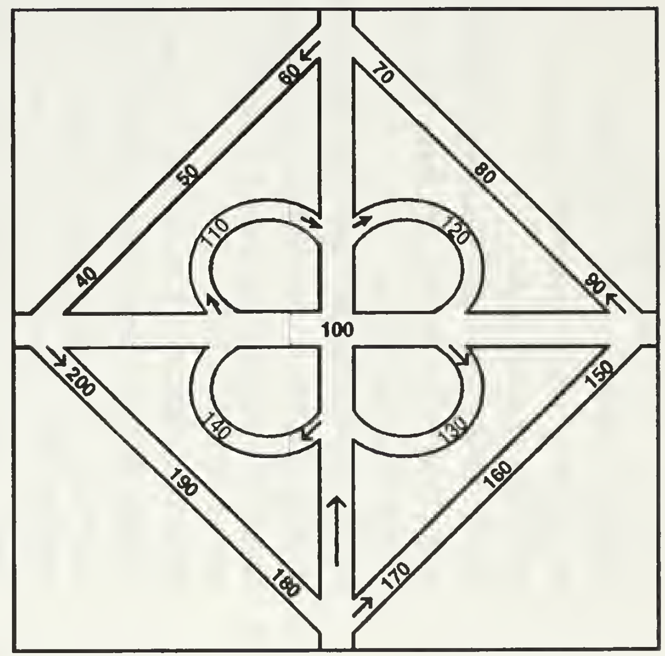
POST QUANTITY

- Single
- Three
- Two
- Other

SUBSTRATE MATERIAL

- Sheet Aluminum
- Extruded Aluminum
- Aluminum Blank
- Plywood
- Other

LOCATION ON RAMPS



SCANTRON FORM NO. F-9717-MDT

P4 3596 -216- 5 4 3 2 1

1. **ROUTE #** – Route designation (e.g., P-2), left-hand justified.
2. **SECTION** – Section number (e.g., 2104).
3. **MILE POST** – Mile post location of sign (e.g., 317).
4. **DIVISION** – (e.g., Missoula).
5. **ROUTE TYPE** – I-interstate, P-primary, S-secondary, U-urban, X-local.
6. **DIRECTION** – Direction of travel (north, south, east, west).
7. **LANES** – Number of lanes.
8. **BACKGROUND COLOR** – Main color of sign (e.g., blue).
9. **LEGEND COLOR** – Color of letters and numbers (e.g., white).
10. **SIGN SIZE** – Height of sign bottom to top, left-hand justified. Length from side to side, left-hand justified, (e.g., 42" x 96").
11. **MOUNTING HEIGHT** – From the bottom edge of sign to the roadway surface.
12. **INSTALLATION** – Date sign was installed from date tag (e.g., Jan 11, 1980).
13. **POSITION** – Relative to roadway (R-right, L-left, O-overhead, M-median).
14. **ORIENTATION** – The direction sign is facing (N, S, E, W, NW, NE, SW, SE).
15. **SHAPE** – Shape of sign (rectangle, triangle, octagon, etc.).
16. **CONDITION** – Visual assessment of sign condition.

E – <u>EXCELLENT</u>	sign is in new condition.
G – <u>GOOD</u>	sign has been in service, but shows little aging.
F – <u>FAIR</u>	sign showing deterioration but has years of service remaining, (needs cleaning).
P – <u>POOR</u>	sign has significant deterioration and should be replaced shortly, (peeling letters, bullet holes). Use retroreflectometer.
R – <u>REPLACE</u>	sign must be replaced immediately (not readable).

17. **SIA** – Specific intensity per unit area. Measurement of the sign retroreflectivity made with calibrated retroflectometer.
18. **LATERAL OFFSET** – Distance from pavement edge to edge of sign.
19. **POST TYPE** – Wood, steel, other. Explain in comments, such as 4" x 6" wood, non-breakaway, steel U post, etc.
20. **SYMBOL** – Is the sign a symbol sign (Y-yes, N-no, P-partial)
21. **POST QUANTITY** – 1-single post, 2 -two post, 3-three post, 4-other. Explain under remarks/comments.
22. **SUBSTRATE MATERIAL** – <u>Sheet Alum</u> – made up of multiple pieces.
    <u>Extruded Alum</u> – formed alum.
    <u>Alum Blank</u> – normally a stand-alone sign.
    <u>Plywood</u> – high density plywood.
    <u>Other</u> – such as an historical marker, etc. Explain under comments.
23. **INSPECTION DATE** – Date sign is inspected (Jan 13, 92).
24. **MUTCD NUMBER** – Uniform code number (e.g., R1-1, W1-2A). (Please enter uniform code number under comments section.)
25. **LEGEND** – **Alphabetic signs** – Message as shown on sign (e.g., stop).
    Symbolic signs – Meaning of sign (curve right). When entering a legend, enter under comments section.

Appendix E: Design Sign Calculation Method

Design Sign Calculation Method

The following discussion and example calculations are given to illustrate the methodology utilized to establish the design sign areas for the various color groups of signs.

To determine the sign area representative of the White on Red signs, the width and height of those signs sampled in the District is used to obtain the area of the sign. An average, weighted by the actual occurrence of that sign in the sample, was then determined. This weighted average, or composite, most accurately represents the signs of this type within the district. Similar calculations were performed for the sign types in the other Districts.

Following this sample calculation, is the remainder of the Missoula District calculations. Other District calculations follow the same calculational logic.

White on Red					
Width	Height	Qty	Area Ft2	Q*A	**Design Average Sq. ft.**
30	30	15	6.25	93.75	**7.4722**
36	36	12	9	108	
		27		201.75	

Composite
11.3021 .= the sum of (Qty*A)/(the Sum of Qty.) for all sign types.

Project Calculations

Missoula District Design Sign

Black On White						**Composite**
Width	Height	Qty	Area Ft2	Q*A	**Design Average Sq ft.**	**11.30208**
18	24	1	3	3	**5.00625**	
21	15	1	2.1875	2.1875		
24	24	2	4	8		
24	30	25	5	125		
36	48	1	12	12		
		30		150.1875		

Black on Yellow					
Width	Height	Qty	Area Ft2	Q*A	**Design Average Sq ft.**
30	30	21	6.25	131.25	**7.696809**
36	36	3	9	27	
48	48	1	16	16	
24	18	2	3	6	
18	18	6	2.25	13.5	
48	36	14	12	168	
		47		361.75	

White on Green					
Width	Height	Qty	Area Ft2	Q*A	**Design Average Sq ft.**
114	36	1	28.5	28.5	**19.26293**
120	24	2	20	40	
120	30	3	25	75	
120	36	2	30	60	
120	48	3	40	120	
120	60	3	50	150	
144	30	1	30	30	
144	60	1	60	60	
54	30	1	11.25	11.25	
84	36	2	21	42	
30	30	15	6.25	93.75	
36	36	12	9	108	
48	42		14	0	
72	20		10	0	
90	30	1	18.75	18.75	
96	18		12	0	
96	24		16	0	
96	30	1	20	20	
96	36	7	24	168	
96	42	1	28	28	
96	48	2	32	64	
96	54		36	0	
		58		1117.25	

White on Red					
Width	Height	Qty	Area Ft2	Q*A	**Design Average Sq ft.**
30	30	15	6.25	93.75	**7.472222**
36	36	12	9	108	
		27		201.75	

Appendix F: SMS Training Outline

Modules in the SMS: Inventory, Dictionary, Utilities, Quit

INVENTORY

File Maintenance - *first step for data entry, analysis, etc.; You must select or create a file to work on.*

-Selects files for further activities, creates files, renames files, deletes files, backs up files. Once this is done, automatically will go back to previous menu screen.

Update Signs - *allows user to add signs to the inventory, set default values for sign data, locate or search for signs, and update inspection records.*

Default

Add

Locate

Inspection Update

Quit

Route Name Table - *allows user to add, delete, edit route names to be used in entering and manipulating data, eliminating incorrect spellings, data errors, etc...*

Inventory Reports - *allows the user to generate different types of reports based on different criteria*

General Inventory

Inspection History

Backing

Sheeting

Face

Quit

DICTIONARY - database of MUTCD codes, legends, and standard sizes for signs.

Add

Locate

Report

Quit

UTILITIES - used to set parameters for environmental variables to refine sign life projection analyses.

Define parameters

Required Ra Tables

Update Ra Equations

Calculate Results

Quit

QUIT - designed for exit of SMS, allowing proper backup of files, changes, etc...